DSN Ground Communications Facility

R. H. Evans

TDA Engineering Section

A functional description of the GCF and its relationships with other elements of the DSN and NASCOM is presented together with development objectives and goals and comments on implementation activities in support of Flight Projects.

I. Introduction

The GCF is one of the three elements of the DSN. The GCF provides for transmission, reception, and monitoring of Earth-based point-to-point communications between the Deep Space Stations (DSSs) (one of the DSN elements), and the Network Operations Control Center (NOCC) (the other element) located at JPL, Pasadena, and to the Mission Operations Control Center (MOC) at JPL. Voice, teletype, high-speed data, and wideband data channels of the world-wide NASA Communications Network (NASCOM) are utilized for all long-distance circuits, except those between JPL and the Goldstone Deep Space Communications Complex (GCSCC). Goddard Space Flight Center (GSFC) NASCOM Engineering has delegated the responsibilities for planning, budgeting, design, implementation, operation, and maintenance of the communications requirements between Goldstone and JPL to the DSN GCF. Additionally, the GCF provides communications services between the DSSs at each geographic communications complex (Madrid, Australia, and Goldstone, CA.) via intersite microwave system capabilities, and between separated areas of the NOCC at JPL via 230 kbit/s wideband data channels. Also, voice communications are provided within the stations, between the stations, within the complexes, and within the NOCC. The GCF is comprised of five subsystems; Voice, Teletype, High-Speed Data, Wideband Data and Monitor and Control. The DSN Tracking and Data Acquisition Engineering

Office of JPL provides the technical direction and systems management of the GCF, and acts as the representative of NASCOM for switching and interconnect functions on the west coast.

II. GCF-NASCOM Interrelationships

The interrelationships at the programmatic level between JPL's DSN GCF and the NASCOM network, managed, engineered, and controlled at GSFC, are characterized as follows:

A. NASCOM

(1) Provides long-haul operational ground communications in support of all NASA projects and mission activities including those supported by the DSN.

(2) Accepts and supports communications requirements established by the DSN and validated through continuing consultation and review.

(3) Establishes in consultation with the users the basic characteristics of the NASCOM systems, such as teletype line rate and block header formats for switching, and the user electrical interfaces.

B. GCF

(1) Provides ground communications for all DSN missions and uses the services of NASCOM.

(2) Establishes additional characteristics of all GCF subsystems on an end to end basis such as block multiplexing, error correction, and monitoring and control.

III. Objectives and Goals

The primary objectives of the GCF are to provide highest quality point-to-point transfer of operational data within the DSN and provide simple user and NASCOM electrical and operational interfaces. These objectives are being met by:

(1) Providing automatic message switching and routing.

(2) Providing data transmission subsystems that are as transparent to the users as possible.

(3) Minimizing project dependent equipment within the GCF.

(4) Providing a centralized common user data records capability.

The goals of the GCF are to provide highly reliable and cost-effective data transmission while continuing an adequate capability balance for multiple mission users, and include:

(1) Equipment and routing redundancy to minimize single-point-of-failure impact.

(2) Error performance which provides essentially block-error-free throughput.

(3) Design coordinated and consistent with the NASCOM Development Program.

IV. Configuration and Functional Subsystem

The current GCF configuration, including the related NASCOM interfaces and functions, is illustrated in Fig. 1. This configuration illustrates the long-haul communication circuit services external to JPL and Deep Space Communications Complexes (except circuits between the Goldstone Complex and JPL) are the responsibility of NASCOM. The voice, teletype, high-speed data, wideband data, and monitor and control subsystems point-to-point communications are serviced by this Fig. 1 configuration.

A. High-Speed Data Subsystem

This subsystem shall consist of GCF assemblies that switch, transmit, record, process, distribute, test, and monitor digital data and is used for transmission of:

(1) All digital data for the DSN command, tracking, and monitor control systems.

(2) All low or medium rate data of the DSN Telemetry System and the DSN Test and Training System.

The High-Speed Data Subsystem provides a capability for transmitting and receiving the serial bit stream formatted data over a single four-wire properly conditioned alternate voice/data channel having a 3.0-kHz bandwidth. This serial bit stream is impressed on communication circuits at a continuous line bit rate divided into message segments referred to as high speed data blocks.

Two types of data blocks are used:

(1) Data blocks containing user data bits to be transmitted.

(2) Filler blocks containing filler data bits provided by GCF when the user data bit/block rate is insufficient to maintain the contiguous bit/block rate required for continuous line monitoring and error control.

The current plans for the GCF Mark III period are to provide the functional capabilities illustrated in Fig. 2. The GCF High-Speed Data Subsystem is standardized on a 1200-bit block size (message segment) and a line bit rate of 7200 bits/s. The other planned changes include conversion from a 33-bit to a 22-bit error detection encoding/decoding polynomial code and increasing the number of bits reserved in the data block ending from 36 to 40 bits. The 40-bit block ending with the 22-bit code provides for numerical serialization and acknowledgement numbers for error correction by retransmission for short outages or errors in GCF end-to-end data transmission.

The error correction capability will significantly reduce the post pass time required for non-real-time replay of blocks received in error to complete the intermediate data record. Figure 3 illustrates the High-Speed Data Subsystem transitional configuration that was planned for the CY 1977 and CY 1978 time period. The transitional configuration (old and new configurations separately or in combinations operational and useable) is required to provide continuous support for ongoing and new projects starting up until the conversion from the old Ground Data System to the new one is completed for support of the Voyager and Pioneer Venus Projects, and to support the continued extended mission of the Viking Project thru early CY 1979. The dual-mode configuration became

operable and useable to support DSN System Testing at the conclusion of acceptance test demonstrations of the Error Detection Correction (EDC) and the High-Speed Switch (HSW) Software in November of CY 1977. The added new computer to computer switched interface to the Mission Control and Computing Center (MCCC), although operable and useable for DSN-MCCC testing, will not be fully operational till June CY 1978.

B. Wideband Data Subsystem

The Wideband Data Subsystem consists of assemblies that switch, transmit, receive, process, distribute, test and monitor data requiring the use of bandwidths greater than those provided by standard high-speed data channels. The GCF Wideband Data Subsystem functionally illustrated in Fig. 4, together with a listing of functional capabilities provided, includes standard wideband circuits as well as all intersite-microwave (area microwave) capabilities. The Wideband Data Subsystem is used for the transmission of:

(1) All DSN Telemetry System high-rate data that exceed High-Speed Data Subsystem capabilities.

(2) Data interchange between the NOCC and GCF Comm Terminal at JPL.

(3) Data interchange between DSSs within a complex via intersite microwave, including critical timing signals.

(4) Simulation System Data from the Mission Control and Computing Center/Mission Operations Center to the DSSs.

(5) DSN Test and Training System data from the Network Operations Control Center to the DSSs.

The wideband data circuits for interchange of data between the DSSs and JPL are impressed with serial bit streams at a continuous line rate typically 27.6, 28.5, 50, 56, 168 or 230.4 kbits/s divided into 2400 or 4800 bit message segments (data blocks). (In CY 1978 the 27.6, 28.5 and 50 kbits/s rates will be deleted). Similar to the high-speed data subsystem the blocks are either data blocks, or filler blocks inserted when the user data load is insufficient to maintain contiguous data blocks on line.

C. Voice Subsystem

The Voice Subsystem consists of GCF assemblies that switch, transmit, receive, distribute, test, and monitor transmissions originally generated in vocal form, and includes internal voice communications within the Deep Space Station Communication Complexes, DSSs, and the NOCC. The sub-system service provides capabilities between those areas and to non-DSN area interfaces as follows:

(1) NOCC and DSS

(2) NOCC and MCCC/MOC (or remote MOC)

(3) MOC and DSS for Command System backup.

The Voice Subsystem functional capabilities and key characteristics include:

(1) Standard voice-data grade circuits for all traffic.

(2) Conferencing capability on one interncontinental circuit during noncritical periods for all deep space stations supporting a single project (individual circuits for each DSS during critical periods, resources permitting).

(3) User controlled intercomm switching.

(4) Circuits used for high-speed data transmission (backup) if required.

(5) Voice traffic recording in the central communications terminal upon request.

D. Teletype Subsystem

This subsystem consists of assemblies that switch, transmit, receive, distribute, test and monitor digital signals originally generated in Baudot format at a teletype (TTY) line rate of 100 words per minute. The operational use of teletype continues to be de-emphasized and is used primarily for emergency-backup operational transmissions and administrative communications. Service functions and key characteristics include:

(1) Handling Air Force Eastern Test Range (AFETR) generated predicts for DSN initial acquisition.

(2) Transmitting non-operational messages between the JPL Message Center and other locations.

(3) Use of standard NASCOM format and the NASCOM communications processor for message switching.

(4) Employment of time division multiplexing techniques to reduce trunk circuit costs.

Conversion to the new eight-level standard will be made when NASCOM resources permit. This conversion is now planned for the CY 1979 to CY 1980 time frame.

V. Typical Configuration

The DSN GCF is designed for multiple mission support. Improvements and additions are integrated to meet new era and project requirements (Voyager and Pioneer-Venus require-

ments being added at present- for example) while continuing to support the Viking, Helios, and Pioneer 6 through 11 Projects. Figure 5, in general, illustrates the GCF configuration for support of these projects. Additionally, remote information centers and other non-DSN NASCOM-serviced installations on the West Coast are serviced through the NASCOM West Coast Switching Center on integral part of the GCF 20/Central Comm Terminal at JPL.
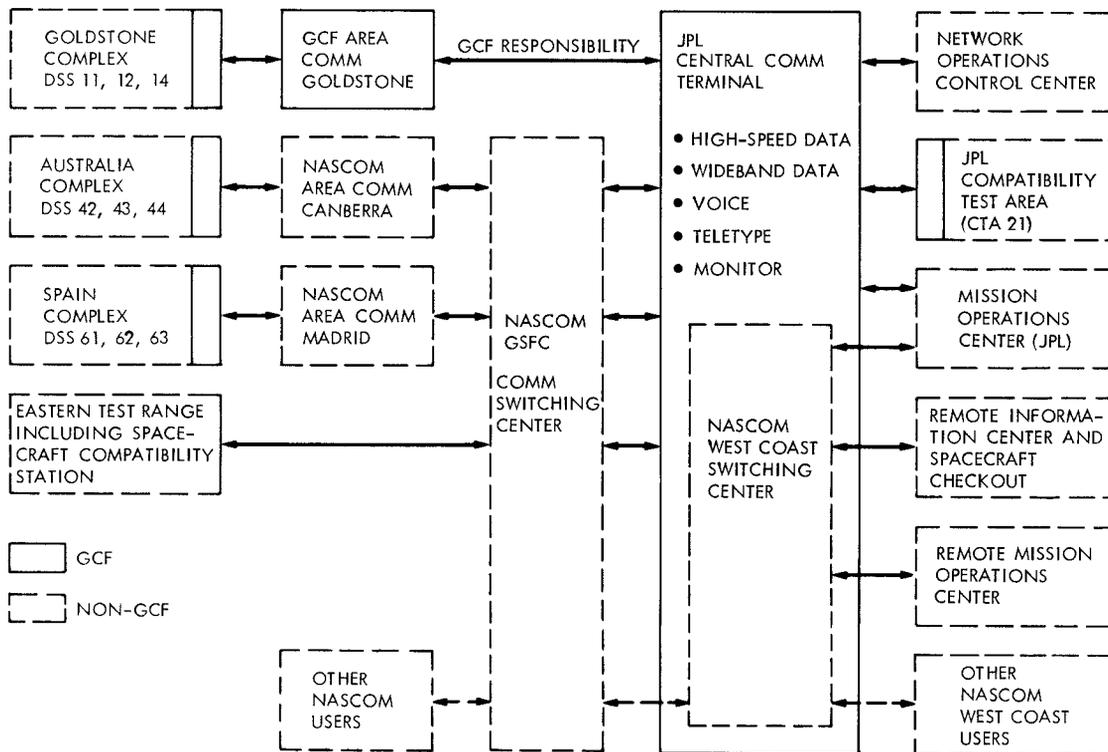
Fig. 1. GCF configuration
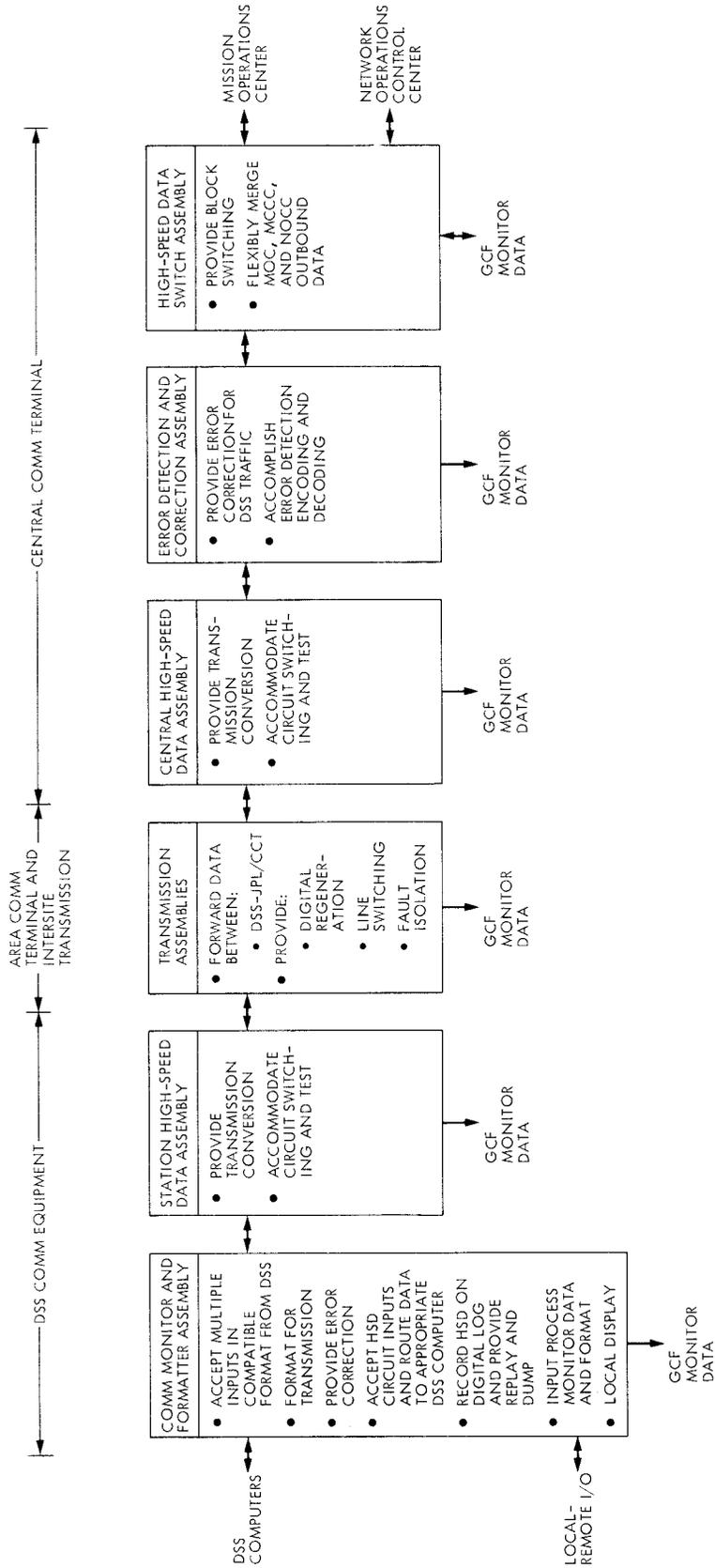
Fig. 2. GCF high-speed data subsystem functional capabilities
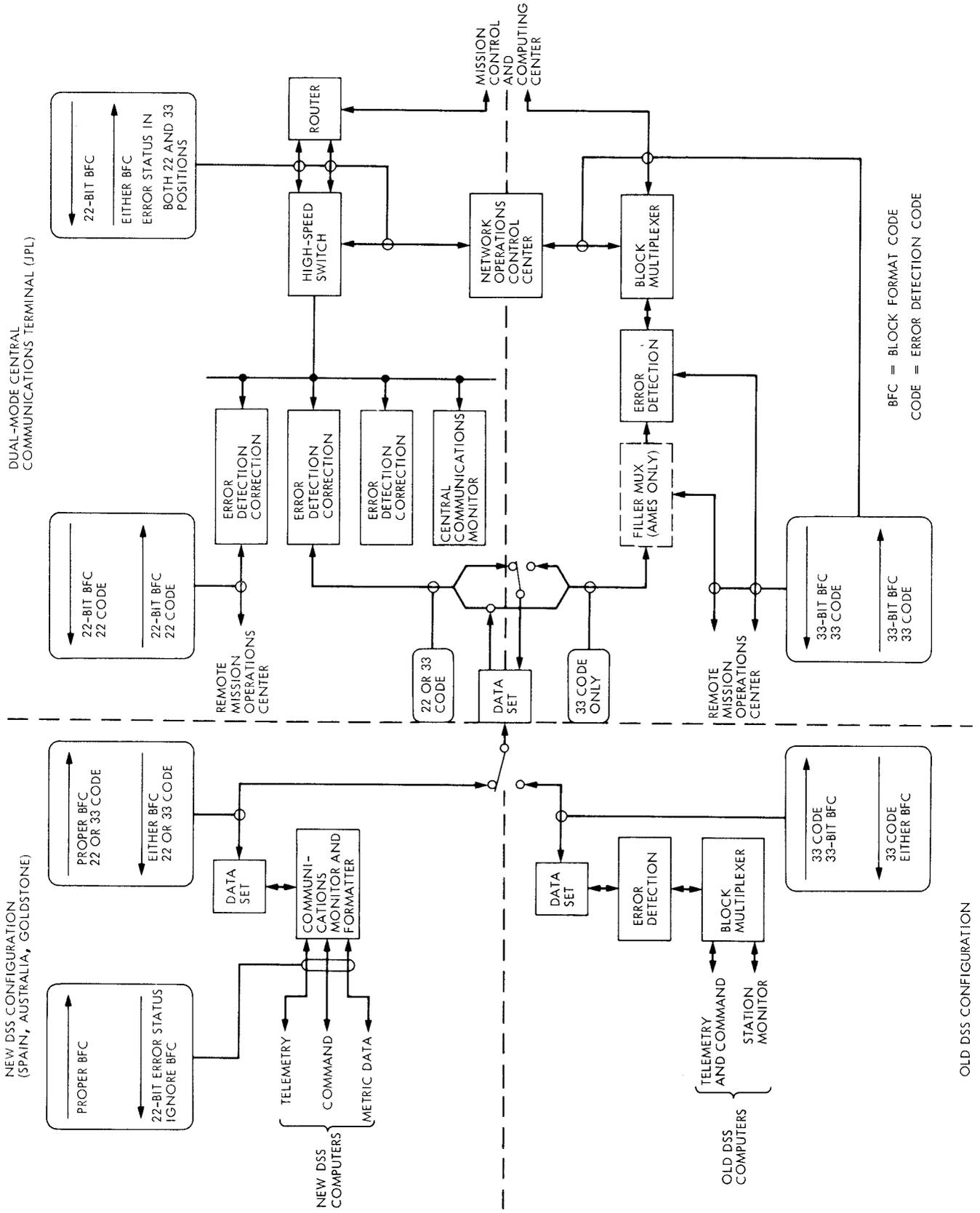
Fig. 3. GCF high-speed subsystem configuration and interfaces, CY 1977 and 1978

BFC = BLOCK FORMAT CODE
CODE = ERROR DETECTION CODE
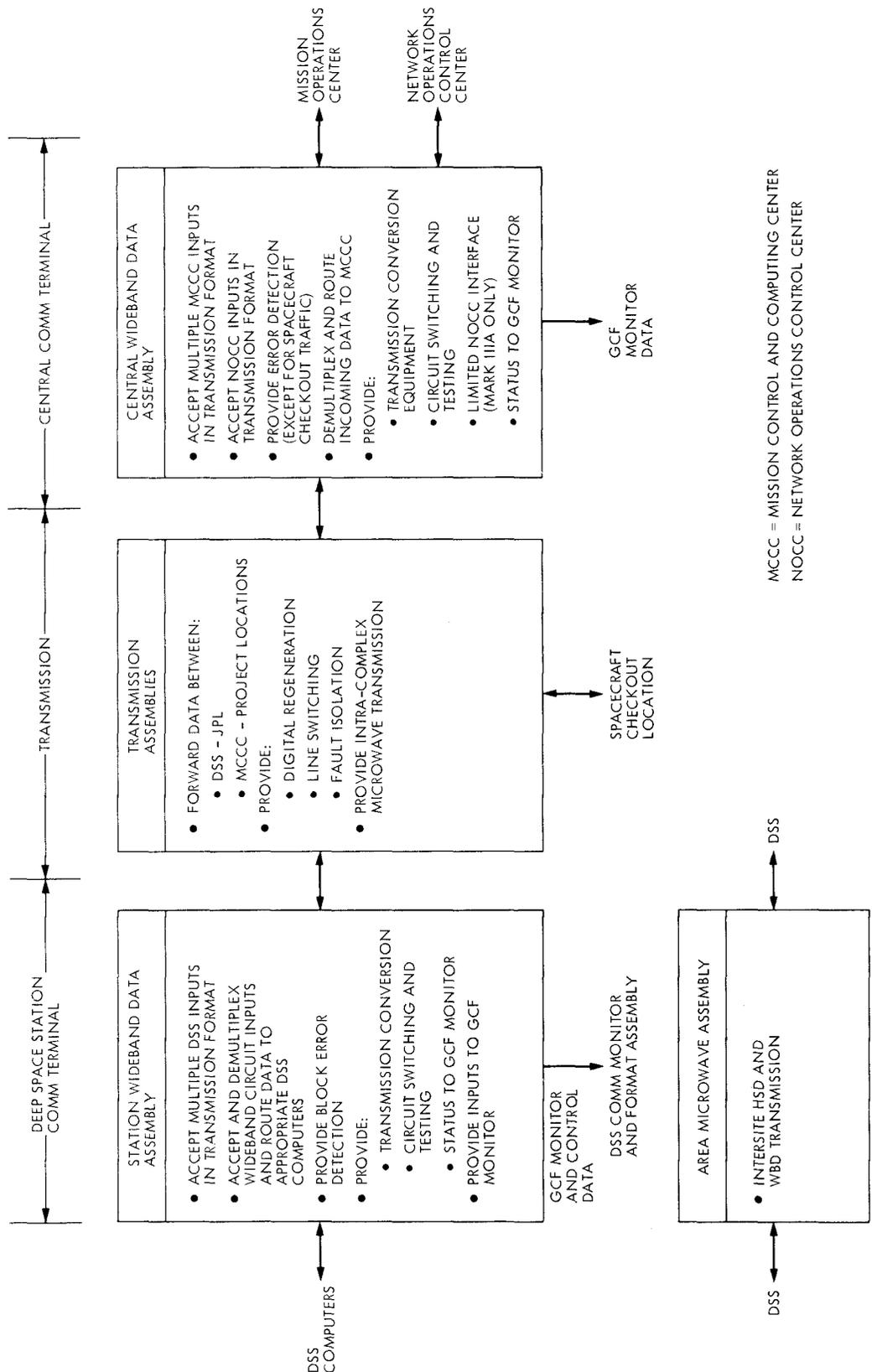
Fig. 4. GCF wideband subsystem

DEEP SPACE STATION COMM TERMINAL

TRANSMISSION

CENTRAL COMM TERMINAL

MISSION OPERATIONS CENTER

NETWORK OPERATIONS CONTROL CENTER

STATION WIDEBAND DATA ASSEMBLY

- ACCEPT MULTIPLE DSS INPUTS IN TRANSMISSION FORMAT
- ACCEPT AND DEMULTIPLEX WIDEBAND CIRCUIT INPUTS AND ROUTE DATA TO APPROPRIATE DSS COMPUTERS
- PROVIDE BLOCK ERROR DETECTION
- PROVIDE:
  - TRANSMISSION CONVERSION
  - CIRCUIT SWITCHING AND TESTING
  - STATUS TO GCF MONITOR
  - PROVIDE INPUTS TO GCF MONITOR

TRANSMISSION ASSEMBLIES

- FORWARD DATA BETWEEN:
  - DSS – JPL
  - MCCC – PROJECT LOCATIONS
- PROVIDE:
  - DIGITAL REGENERATION
  - LINE SWITCHING
  - FAULT ISOLATION
- PROVIDE INTRA–COMPLEX MICROWAVE TRANSMISSION

CENTRAL WIDEBAND DATA ASSEMBLY

- ACCEPT MULTIPLE MCCC INPUTS IN TRANSMISSION FORMAT
- ACCEPT NOCC INPUTS IN TRANSMISSION FORMAT
- PROVIDE ERROR DETECTION (EXCEPT FOR SPACECRAFT CHECKOUT TRAFFIC)
- DEMULTIPLEX AND ROUTE INCOMING DATA TO MCCC
- PROVIDE:
  - TRANSMISSION CONVERSION EQUIPMENT
  - CIRCUIT SWITCHING AND TESTING
  - LIMITED NOCC INTERFACE (MARK IIIA ONLY)
  - STATUS TO GCF MONITOR

DSS COMPUTERS

GCF MONITOR AND CONTROL DATA

DSS COMM MONITOR AND FORMAT ASSEMBLY

SPACECRAFT CHECKOUT LOCATION

GCF MONITOR DATA

AREA MICROWAVE ASSEMBLY

- INTERSITE HSD AND WBD TRANSMISSION

DSS

DSS

MCCC = MISSION CONTROL AND COMPUTING CENTER

NOCC = NETWORK OPERATIONS CONTROL CENTER

Fig. 5. DSN support locations and GCF-NASCOM circuit requirements

GOLDSTONE, CALIF[a]

DSS 11
2 VOICE
1 MICRO-
WAVE
CHANNEL

DSS 12
2 VOICE
1 HSD

DSS 14
2 VOICE
2 HSD
2 WB
1 MICRO-
WAVE
CHANNEL

GCF-10
AREA
SWITCHING
CENTER

JPL, PASADENA

MCCC
OPERATIONS/
SIMULATION
AREAS

NETWORK
OPERATIONS
CONTROL
CENTER

VIKING/
VOYAGER
MISSION
SUPPORT
AREAS

PASADENA, CA

VOICE-HSD-TTY-WB

GCF 20
COMM
TERMINAL[b]

JPL

REMOTE
MISSION
OPERATION
CONTROL

REMOTE
INFORMAT
CENTERS

SPAIN[a]

CEBREROS

DSS 62
2 VOICE
1 HSD

ROBLEDO

DSS 61/63
2 VOICE
3 HSD
1 WB

MADRID
NASCOM
SWITCHING
CENTER

AUSTRALIA[a]

HONEYSUCKLE

DSS 44
2 VOICE
1 HSD

TIDBINBILLA

DSS 42/43
2 VOICE
3 HSD
1 WB

CANBERRA
NASCOM
SWITCHING
CENTER

GREENBELT, MD

GSFC
NASCOM
SWITCHING
CENTER

GSFC

VOICE-HSD-TTY-WB

[a]DEEP SPACE COMMUNICATIONS COMPLEX

[b]ALSO NASCOM'S WEST COAST SWITCHING CENTER

HSD = HIGH-SPEED DATA
MCCC = MISSION CONTROL AND COMPUTING CENTER
TTY = TELETYPE
WB = WIDEBAND

17